

A Study of Physiological Characterization of Wheat (*Triticum Aestivum* L) Varieties

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ABSTRACT

*Physiological Characterization of wheat (*Triticumaestivum* L.) genotypes were characterized with respect to heat stress and spot blotch disease under four environmental conditions viz. no stress (E1), stress due to spot blotch (E2), heat stress (E3) and combined stress (E4) along with molecular characterization using 28 SSR markers (associated with tolerance against heat stress and resistance against spot blotch disease). The experimental materials were evaluated in randomized block design (RBD) factorial. Observation on 1000-grain weight, grain filling duration (GFD), plant height, peduncle length, spike length, disease severity and area under disease progress curve (AUDPC) were recorded. Significant differences were observed among the genotypes for all the traits under consideration. Genotype \times environment were found non-significant. The lowest performance of the genotypes under combined stress condition (E4) was recorded. The individual impact of heat stress with respect to performance of the genotype was found significantly higher than that caused by spot blotch disease. Raj 3765 for 1000-grain weight, WH 760 for GFD, Yangmai-6 for plant height, PBW 343 for peduncle length and HD 2733 for spike length, showed stable performance across the environment. On the basis of stress susceptibility index (SSI) the genotypes WH 760, DBW 14 and Raj 3765 were found better for the characters, 1000-grain weight and GFD. The overall disease severity was found maximum under heat stress condition. Similarly genotypes were having relatively more AUDPC under heat stress condition.*

1. Introduction

Wheat (*Triticumaestivum* L.) is one of the most widely grown cereals in the world. Its productivity in the coming decades, like that of most major crops, is threatened by impending climate change; the global mean temperature is predicted to rise by 0.3°C per decade. Low temperature (<12°C) applied during germination and seedling emergence in wheat resulted in poor and uneven emergence (Hossain et al. 2012), while spring wheat exposed to high temperature (30–35°C) resulted in a decrease in time to flowering, grain set, and physiological maturity, ultimately reducing grain yield (Hossain et al. 2012). Currently crop models are evolving to accommodate the nonlinear response to temperature and the step reduction in grain number associated with a short period (1–2 day) of heat or cold shock. The association mapping approach combines phenotypic with genotypic data to identify genomic locations associated with variation in a given trait. Its ability to resolve marker/trait association depends upon the extent of linkage disequilibrium present in the association panel (Gupta et al. 2015). Linkage disequilibrium (LD) refers to the nonrandom association of alleles at two or more loci in a general population. More LD in A and B genome is due to recent evolution of D genome about 1–2 million years compared to A and B genome which evolved about 7 million years ago. The association mapping approach has been applied to a range of crop species, facilitating the discovery of many quantitative trait loci. In wheat, for example, loci associated with variation in kernel size and milling quality, grain yield, resistance to disease and various agronomic traits (Bordes et al. 2014) have been located in this way. Several association mapping studies have been

conducted to dissect the genetic basis of grain yield in wheat (Kidane et al. 2017). Assessment of nature and magnitude of genetic variation, genetic resource characterization and identifying a marker for the tolerance would be a practicable solution for development of improved cultivars resistant to abiotic stresses and for efficient management and utilization of germplasms in regions where stress occurs commonly. Keeping all above consideration in view, the present investigation was carried out to identify polymorphic SSR markers to characterize the promising lines and to determine the extent of genetic divergence among the lines, followed by a survey of markers for their association to heat tolerance.

2. Physiological characterization of wheat (*Triticumaestivum*)

In last few years, world climatic conditions have been drastically changed. Most part of the India is under low water availability especially in Alwar region. In Alwar region, 29% of the total cultivable area faces drought condition out of which 10% is under severe drought (Anonymous 2003). Drought and water shortages threaten the agricultural productivity of many developing countries, especially in Alwar region, to feed their ever growing population. In addition abiotic stresses such as extreme temperature, drought, heat, salinity, mineral deficiency and toxicity are frequently encountered by plants in both natural and agricultural systems. Across a range of cropping systems around the world, abiotic stresses are estimated to reduce yields to less than a half of that possible under ideal growth conditions. In addition abiotic stress reactions, especially to water deficiency and high level of salts, are complex morphological and physiological phenomenon in

plants. Drought stress not only affects the morphology but also severely affects the metabolism of the plant, physiology and biochemical responses in plants. These responses include stomatal closure, repression of cell growth and photosynthesis and activation of respiration. It is a permanent constraint to agricultural production in many developing countries and an occasional cause of losses of agricultural production in developed ones. Therefore, physiological and biological approaches have a great importance in order to understand the complex responses of plants to water deficiency and to develop new varieties. When water is not a limiting factor, Triticum productions with late sowing (with high temperatures in the end of the cycle) have lower yields, mostly as a result of heat stress during grain filling. It has been reported that, during grain filling, increasing temperatures (between 15/10°C and 21/16°C day/night temperatures) counter balances the diminished growth duration, augmenting the filling rate. Caley et al. (1990) and Jenner (1994) further confirmed related data. Shpiler and Blum (1986), working with field trials, also reported that grain maturity develops earlier, producing smaller and shriveled grains, in heat stressed genotypes. Photosynthetic activity is sensitive to high temperature. High temperature increases the radiant energy absorbed by the leaf and, as a consequence, the process of photosynthesis is affected. Therefore, a visible trait such as leaf chlorophyll content can be used along with chlorophyll fluorescence for screening. These processes directly affect photosynthesis and, ultimately, yield. The 'stay green' phenotype can arise in different ways. One approach to achieve a longer photosynthetic period is the use of functional stay-green phenotypes, which show either a delayed onset or a slower rate of senescence with maintaining photosynthetic activity. In cells, senescence-related changes are first detected in the chloroplast. Plants with the 'stay green' trait have been shown to resist drought induced premature plant senescence. Many mutations, referred to as stay green or non-yellowing in various plant species have been reported to maintain leaf greenness after the grain ripening stage. Some 'stay green' mutants can photosynthesize longer and might therefore be expected to give a higher yield; these may be defined as 'functional stay green' mutants.

Characterization of Indian wheat genotypes

The extent of modification depends upon the cultivar, growth stage, duration and intensity of stress. Hence, even at the same level of moisture stress condition, different genotypes show different responses as per their genetic potential for adaptation. Drought stress induces a range of physiological and biochemical responses in plants so that plants are able to develop tolerance mechanisms towards environmental stress. These responses include stomata closure, repression of cell

growth and photosynthesis and activation of respiration, decreased in the water relation, nutrient uptake and grain yield of the wheat cultivars.

Morphological and agronomic traits of wheat have a special role in determining the importance of each trait in increasing yield; therefore, these traits were used in breeding programs which at least led to improving yield and introducing commercial varieties that can withstand seasonal drought stress condition. The biological yield, spike length, number of grains per spike and harvest index showed more direct positive effects on yield. Improving drought tolerance and productivity is one of the most difficult tasks for researchers because under drought prone conditions, plant themselves adopts diverse strategies to combat drought stress depending on the timing, severity and stage of crop growth. In addition to this, the meager availability of drought resistant cultivars further adds to the problem. It is therefore, necessary to appraise and screen wheat genetic resources to identify the sources of the resistance for breeders to construct new wheat varieties. In this view, the major wheat varieties grown in Alwar region were evaluated for their performance in response to drought with a special focus given to morphological, physiological and biochemical parameters.

3. Materials and Methods

Phenotypic Evaluation:

The experimental material was sown in control and polytunnel condition. The genotypes were grown in randomized block design with two replications. Cultivars were exposed to increased artificial temperature from anthesis onwards in plastic sheet tunnel with semi controlled temperature condition. The chamber was set at 35/30°C and 14/10 h day/night, 50/70% relative humidity and illumination of 335 µmol. For this, two replications were to be evaluated under natural conditions followed by exposure towards enhanced heat by covering it with plastic sheet tunnels, simulating the condition of greenhouse effect. All the recommended cultural and agronomical practices were followed uniformly to raise good crop. Data were recorded for each genotypes towards both the control and stressed environment excluding border effect for eight quantitative characters viz. grain filling duration (GFD), number of effective tillers, spike length (SL), number of spikelets, number of grains per main spike, thousand grain weight (TGW), grain yield (GY) and harvest index (HI) respectively

Plant material:

A total of 19 diverse wheat genotypes from all over the world were selected for the evaluation (Table 1)

Table 1: List of genotypes and their sources

Sl. No.	Varieties name	Source
1	PBW 343	RAU, Pusa
2	C 306	RAU, Pusa
3	Pusa Gold	RAU, Pusa
4	SAWSN 3042	NBPGR, New Delhi
5	Halna	IARI
6	Iepaca Rabe	IARI
7	Sonalika	IARI
8	Kauz/AA/Kauz	IARI
9	AKAW 4189-3	RAU, Pusa
10	Mon's Ald's	IARI
11	SAWSN 3101	NBPGR, New Delhi
12	VL 914	IARI
13	HD 2888	RAU, Pusa
14	AKAW 4008	IARI
15	HD 2285	IARI, Pusa
16	Cuo/79/Prulla	IARI
17	K 0583	RAU, Pusa
18	K 307	RAU, Pusa
19	HD 2733	IARI, Pusa

Plant DNA Isolation

Genomic DNA from all the 19 wheat genotypes was isolated from 30 days old seedlings following modified CTAB extraction method described. A total of 30 markers were selected for the screening of genotypes.

Statistical analysis

difference between two treatments was significant at 1% or 5% level. The genotypic variance (V_g or σ^2_g) and phenotypic variance (V_p or σ^2_p) were obtained from the analysis of variance. Coefficients of variability were used. Heritability was expressed in terms of percentage as defined by (Lush 1949) and was calculated as per given by (Hanson 1956). Genetic advance i.e. expected genetic gain from the selection of 5% superior individuals was estimated and followed by the estimation of genetic advance a percentage of mean.

Molecular Study

Marker polymorphism was used to measure the formativeness of the marker; the PIC for each marker was calculated according to the formula. Genetic similarity estimation and diversity analysis and the genetic association among varieties were analysed by calculating the similarity coefficient for pair-wise comparisons based on the proportions of shared bands produced by primers. The dendrogram based on similarity indices was obtained by UPGMA. The nature and

Mean performance on plot basis was determined by taking the average performance of the plants over the block of particular genotypes. ANOVA preparation was followed by the mean sum of squares where, genotypic mean square was tested against error mean squares by F-test for (v-1) and (v-1) (r-1) degree of freedom both at 1% or 5% level of significance. Standard error was calculated with the help of error mean square by the formula.

$$\text{Error M.S.S. (M.Se)} = \frac{\text{Error sum of square (E.S.S.)}}{\text{Degree of freedom for error (v-1) (r-1)}}$$

extent of diversity between varieties were assessed by identifying the clusters at appropriate phenon levels. All calculations were performed using the NTSYS-pc version 1.10 m software.

4. Results and Discussion

Analysis of variance

Analysis of variance was carried out for the performance of the individual under two environments for all the eight characters. The mean squares due to genotypes were significant for all the given characters below.

Mean performance of genotypes: The mean performance of 19 genotypes with respect to eight quantitative characters studied in the present investigation under two environmental conditions has been furnished in (Table 2 and 3). Here we have assumed HD1733 as a check variety in compare with all the characters mentioned below.

Table 2: Average days to no. of grains/spike, 1000 grains weight, Grain yield/plant, Harvest index of 19 genotypes of wheat in open and polytonal conditions

Sl. No.	Genotype	No. of grains/spike		1000 grains weight (g)		Grain yield/plant (g)		Harvest index (%)	
		Open	Polytonal	Open	Polytonal	Open	Polytonal	Open	Polytonal
1	PBW 343	28.47	20.21	34.14	22.71	13.66	4.16	44.57	37.87
2	C 306	34.26	0.00	42.44	0.00	8.00	0.00	42.74	0.00
3	Pusa Gold	36.1	30.1	32.93	26.24	8.16	4.83	50.04	38.68
4	SAWSN 3042	27.09	0.00	42.32	0.00	11.83	0.00	49.95	0.00
5	Halna	45.00	28.84	30.65	34.94	8.16	10.83	56.04	39.41
6	Iepaca Rabe	11.49	28.05	29.29	37.83	10.70	1.30	69.84	8.98
7	Sonalika	29.12	14.91	37.75	28.23	7.33	2.41	45.79	21.97
8	Kauz/AA/Kauz	48.23	14.05	20.33	29.72	5.24	2.74	46.34	18.59
9	AKAW 4189-3	31.18	13.86	27.66	18.36	7.09	2.18	40.48	16.94
10	Mon's Ald's	19.48	19.02	27.84	19.83	4.66	3.16	44.28	23.69
11	SAWSN 3101	28.89	2.28	30.005	0.69	4.61	0.06	40.55	0.58
12	VL 914	41.85	16.69	35.72	15.75	7.16	2.61	45.89	16.68
13	HD 2888	37.15	14.53	38.10	21.50	6.99	3.08	31.61	17.15
14	AKAW 4008	43.44	29.28	32.12	25.83	9.00	5.50	45.67	35.34
15	HD 2285	29.78	21.11	33.16	17.62	5.99	3.88	42.87	28.39
16	Cuo/79/Prulla	30.44	19.6	34.44	27.55	5.33	2.66	41.53	20.00
17	K 0583	46.74	22.58	40.00	23.23	6.71	2.38	51.17	21.23
18	K 307	26.14	22.15	35.67	22.26	7.50	4.25	45.76	36.68
19	HD2733	33.53	22.89	41.01	22.26	13.74	3.70	60.96	26.43
	Mean	33.07	17.90	33.97	20.76	7.99	3.06	47.34	20.93
	S.Em. +	1.73	1.72	0.89	1.54	0.73	0.44	3.19	2.83
	CD at 5%	5.15	5.13	2.64	4.58	2.17	1.31	9.49	8.42
	CV %	7.41	13.64	3.71	10.49	12.94	20.36	9.54	19.15

Table 3: Estimates of genotypic variance, phenotypic variance, heritability, genetic advance, genetic advance as per cent of mean, genotypic (GCV) and phenotypic coefficient of variation (PCV)

Sl. No.	Characters	Environment	Range	GV	PV	Heritability	GCV	PCV	GA	GA % M
1	Grain Filling Duration (Days)	Open	28.5-38.5	5.25	7.82	67.07	6.77	8.27	3.86	11.43
		Polytunnel	26-34	4.07	6.76	60.23	6.63	8.54	3.23	10.59
2	Total no. of effective tillers	Open	4.8-12.83	3.65	4.41	82.68	27.76	30.53	3.58	52.00
		Polytunnel	4.6-8.3	0.89	1.25	71.31	14.80	17.53	1.64	25.75
3	Spike length (cm)	Open	4.8-10.2	1.77	2.50	70.52	16.77	19.97	2.30	29.02
		Polytunnel	6.09-9.98	1.25	1.44	86.49	13.55	14.57	2.14	25.95
4	No. of spikelet/ear head	Open	25.6-56.19	56.98	65.19	87.40	17.51	18.73	14.54	33.72
		Polytunnel	31.35-52.32	29.34	39.75	73.83	12.35	14.37	9.59	21.86
5	No. of grains/spike	Open	11.49-46.74	84.81	95.88	88.45	27.85	29.61	17.84	53.95
		Polytunnel	0-30.1	84.63	90.59	93.42	51.39	53.17	18.32	102.33
6	1000 grains weight(g)	Open	20.33-42.44	31.54	33.13	95.20	16.53	16.94	11.28	33.22
		Polytunnel	0-37.83	111.60	116.35	95.91	50.89	51.97	21.31	102.68
7	Grain yield/plant (g)	Open	4.6-13.74	6.93	8.00	86.62	32.92	35.37	5.05	63.12
		Polytunnel	0-9.83	4.83	5.21	92.70	71.56	74.59	4.35	142.15
8	Harvest index (%)	Open	31.61-69.84	64.60	85.00	75.29	16.97	19.47	14.43	30.48
		Polytunnel	0-39.41	147.06	163.13	90.14	57.93	61.02	23.71	113.28

Variability Range

The estimates of phenotypic coefficient of variation revealed a wide range of variation ranging from 8.17 for GFD to 74.59 for grain yield per plant. The range of genetic coefficient of variation (GCV) varied from 6.63 (GFD) to 71.56 (Grain yield / plant). The characters grain yield per, HI, number of grains per spike, TGW showed comparatively high genetic coefficient of variation, while other characters have shown moderate to low estimates of genetic coefficient of variation.

Heritability

High heritability was recorded for the characters viz., number of grains per spike, TGW and grain yield, whereas most of the characters under study had moderate to low heritability. The heritability percentage ranged from 67.06 (GFD) to 95.10 (TGW) in open and 60.13 (GFD) to 95.91 (TGW) in polytonal condition (Table 4).

Table 4: Heat susceptibility Index (HSI) of 19 genotypes of wheat (*Triticumaestivum* L.) for grain filling duration, number of grains per spike, 1000 grain weight, grain yield per plant and harvest index

Sl. No.	Genotypes	Heat Susceptibility Index (HSI)										
		Grain Filling Duration (Days)	Score	No. of grains/spike	Score	1000 grains weight (g)	Score	Grain yield/plant	Score	Harvest index	Score	Total score
1	PBW 343	1.32	3.00	0.63	14.00	0.86	9.00	1.15	5.00	0.28	18.00	49.00
2	C 306	0.81	10.00	2.18	1.00	2.57	1.00	1.65	1.00	1.84	1.00	14.00
3	Pusa Gold	1.69	1.00	0.36	15.00	0.52	12.00	0.67	14.00	0.42	15.00	57.00
4	SAWSN 3042	1.13	5.00	2.18	1.00	2.57	1.00	1.65	1.00	1.84	1.00	9.00
5	Halna	0.70	13.00	0.78	9.00	-0.36	15.00	-0.54	18.00	0.55	14.00	69.00
6	Iepaca Rabe	0.77	11.00	-3.14	18.00	-0.75	16.00	1.45	3.00	1.60	3.00	51.00
7	Sonalika	1.08	7.00	1.06	8.00	0.65	11.00	1.11	7.00	0.96	9.00	42.00
8	Kauz/AA/Kauz	1.10	6.00	1.55	3.00	-1.19	17.00	0.79	12.00	1.10	5.00	43.00
9	AKAW 4189-3	1.08	7.00	1.21	6.00	0.86	9.00	1.14	6.00	1.07	7.00	35.00
10	Mon's Ald's	0.97	9.00	0.05	17.00	0.74	10.00	0.53	17.00	0.85	11.00	64.00
11	SAWSN 3101	1.61	2.00	2.01	2.00	2.51	2.00	1.63	2.00	1.81	2.00	10.00
12	VL 914	0.31	17.00	1.31	5.00	1.44	3.00	1.05	9.00	1.17	4.00	38.00
13	HD 2888	0.60	15.00	1.33	4.00	1.12	6.00	0.92	10.00	0.84	12.00	47.00
14	AKAW 4008	1.32	3.00	0.71	11.00	0.50	14.00	0.64	15.00	0.42	16.00	59.00
15	HD 2285	1.04	8.00	0.63	13.00	1.21	4.00	0.58	16.00	0.62	13.00	54.00
16	Cuo/79/Prulla	0.59	16.00	0.78	10.00	0.51	13.00	0.82	11.00	0.95	10.00	60.00
17	K 0583	1.27	4.00	1.13	7.00	1.08	7.00	1.06	8.00	1.08	6.00	32.00
18	K 307	0.69	14.00	0.33	16.00	0.97	8.00	0.71	13.00	0.37	17.00	68.00
19	HD2733	0.72	12.00	0.69	12.00	1.18	5.00	1.20	4.00	1.04	8.00	41.00

Analysis of variance indicated significant differences among genotypes for all characters under study in both the environments. Five genotypes (PBW 343, Pusa Gold, Halna, AKAW 4008, K 307) in polytonal condition showed significantly higher harvest index than HD 2733(C). The investigation involved the study of genetic variability through coefficient of phenotypic and genotypic variation as an index for the amount of potential variability present in the individual economic traits. The range of total variation observed in the eight traits exhibited a wide variation for the traits TGW. Higher value of phenotypic coefficient of variation was obtained in all the cases than the genotypic coefficient of variation for all the characters.

Phenotypic coefficient of variation which measures the total variation in different characters were higher for grain filling duration, total number of effective tillers, spike length and grain yield per plant, while the characters number of spikelets per ear head, number of grains per spike, TGW and harvest index showed low value of phenotypic co-efficient of variation. The result obtained in this study is in agreement with the result of (Kumar et al. 2003) who reported high GCV than PCV for number of effective tillers per plant.

5. Conclusion:

The current study focuses and emphasis on the potential of heat stress to negatively affect crop physiology. Here, we have screened 19 wheat (*Triticumaestivum* L.) genotypes for their tolerance of heat stress. Significant differences were observed among the genotypes for all the traits under consideration. Exploitable extent of genetic variability amongst the entries was present as revealed by considerably higher estimates of mean %. A perusal of similarity coefficients clearly reflected that a very high degree of similarity exists between wheat variety Mon's Ald's and SAWSN 3101 (0.70). On the other hand, the two most distantly related cultivars were found to be AKAW 4008 and PBW 343 (0.034). BARC 4, BARC 170, BARC 311, PSP 3058, WHE014.H04 and GWM 458 were strongly associated with the heat tolerance for traits TGW and BARC 311 was strongly associated with terminal heat tolerance for number of grains/plant respectively. Considering all the parameters it is adjudged that relatively stable genotypes may be evaluated at various agro climatic regions for grain yield and heat tolerance along with other contributing characters and ideal plant type.

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